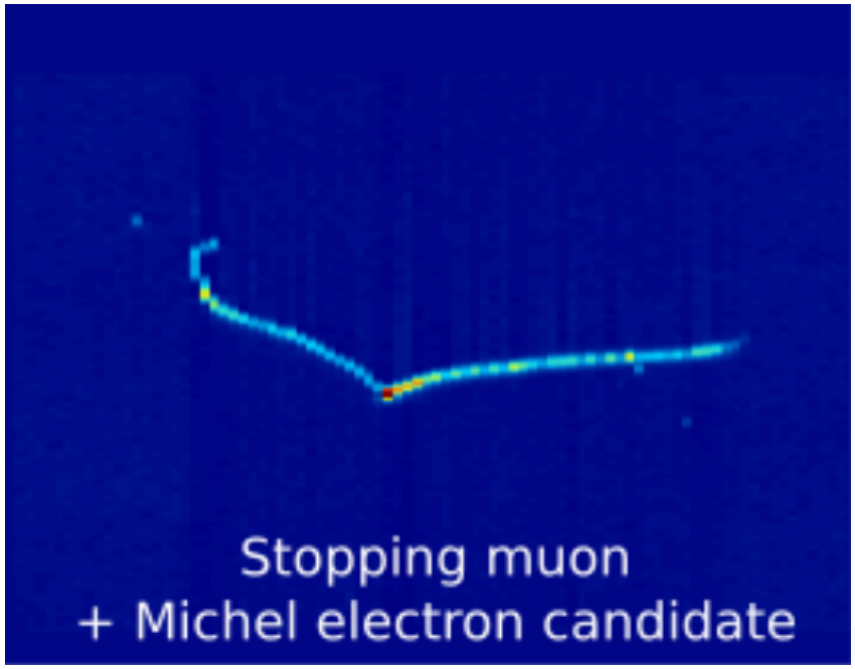
LArIAT in 12+3 Minutes



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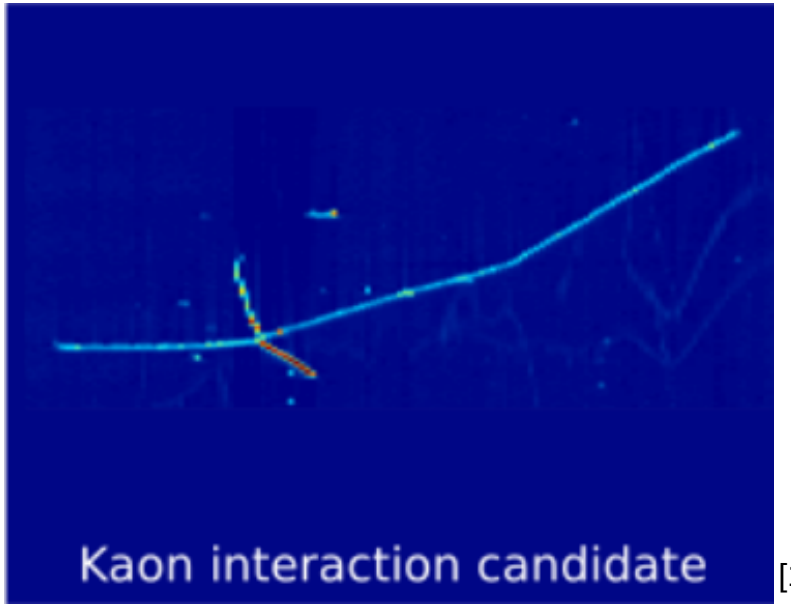


[1]

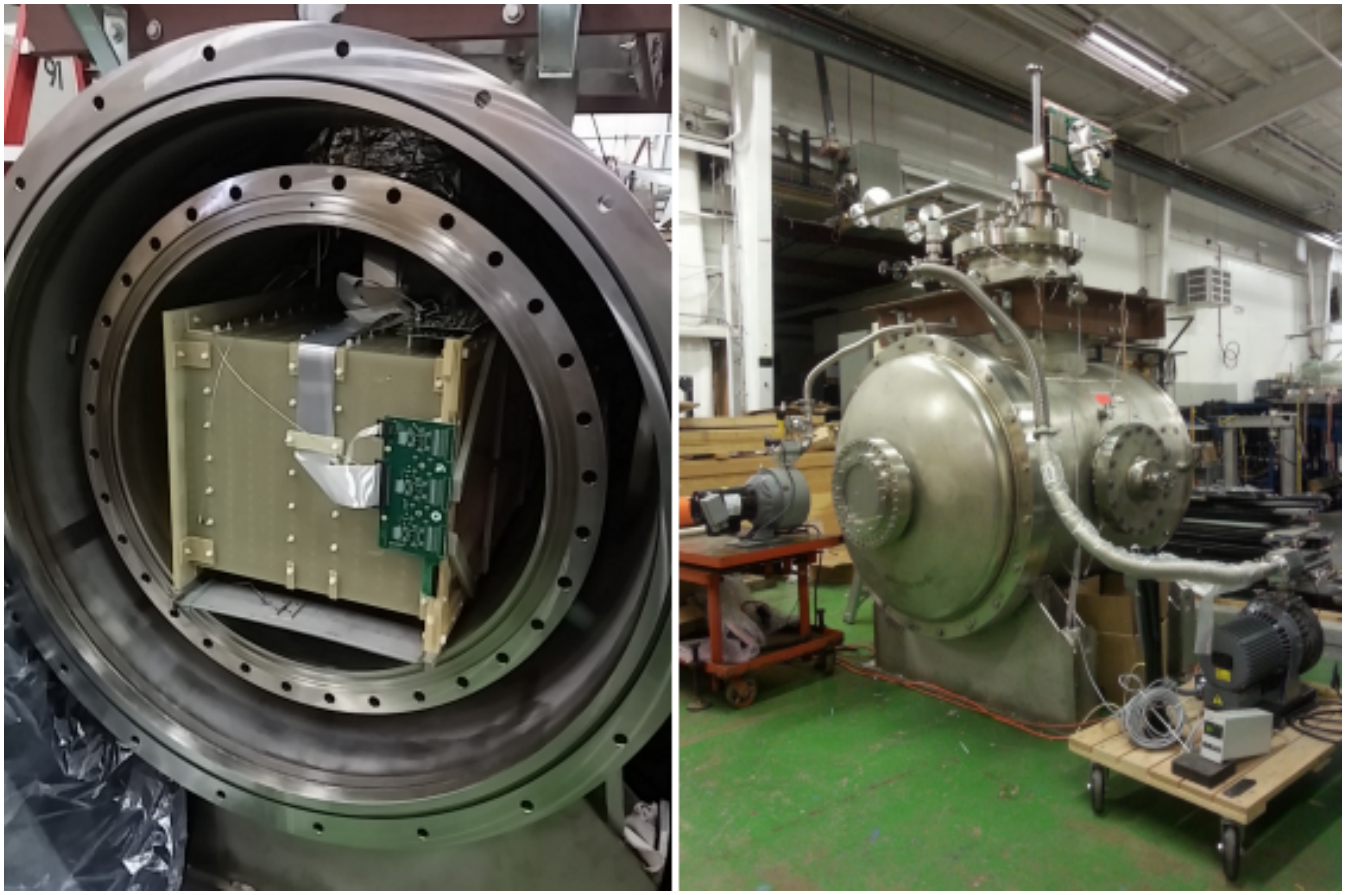
New Perspectives 2020

Matthew King, Yale University
20 July 2020

What is LArIAT?

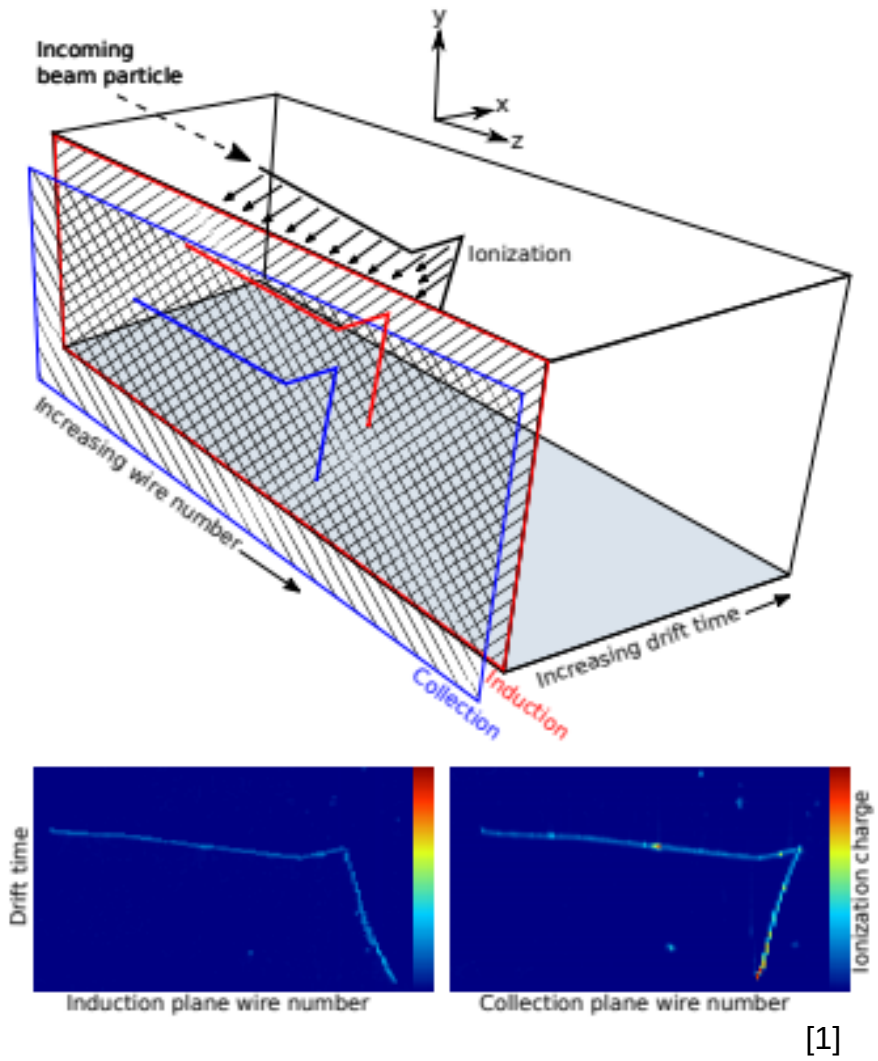
- Liquid Argon In A Testbeam
- LArIAT is a Liquid Argon Time Projection Chamber (LArTPC) in a beam of **known** particles.

Cryostat and TPC refurbished from the ArgoNeuT experiment



[1]

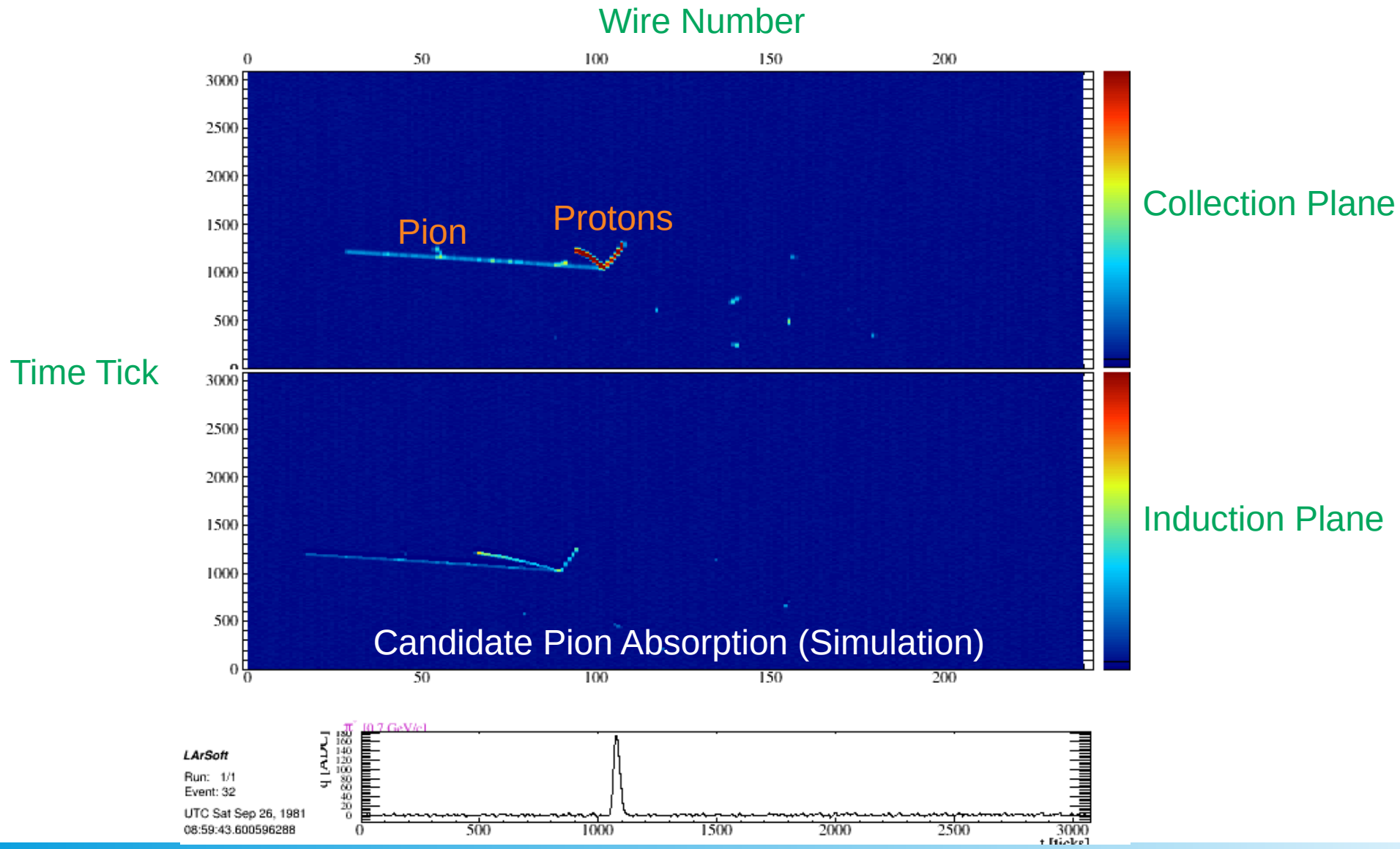
LArTPC Technology



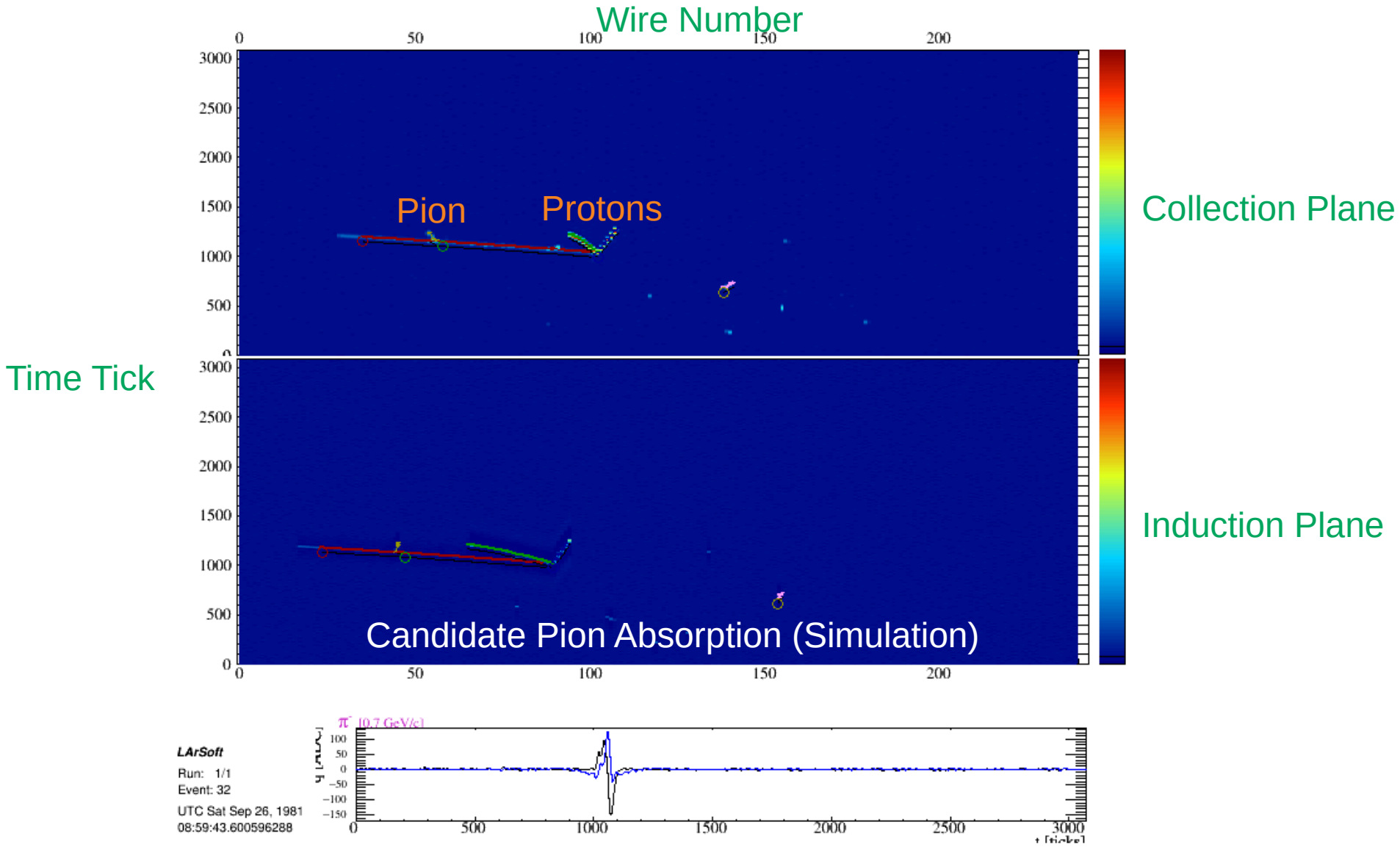
[1]

1) Charged particles ionize and excite argon.
2) Argon scintillates, and the PMTs record the photon within nanoseconds, marking initial time for the event.
3) Ionization electrons drift towards induction and collection planes on the order of hundreds of microseconds.
4) Electrons induce current in the planes and land on the collection plane.

Pions and Protons!

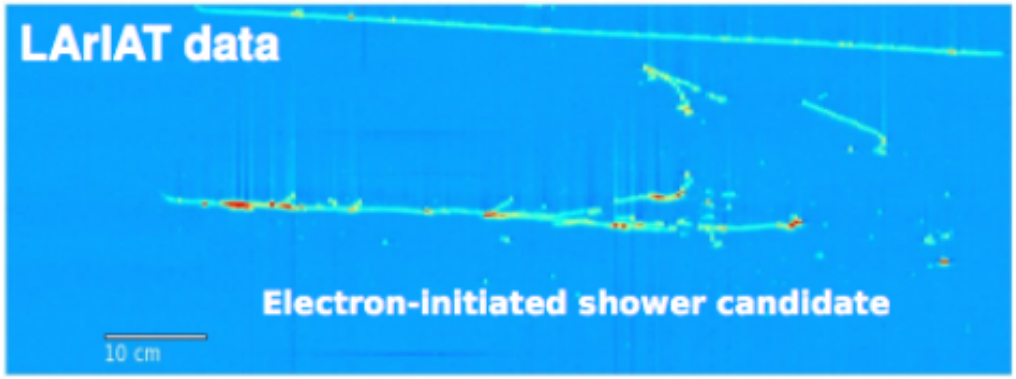


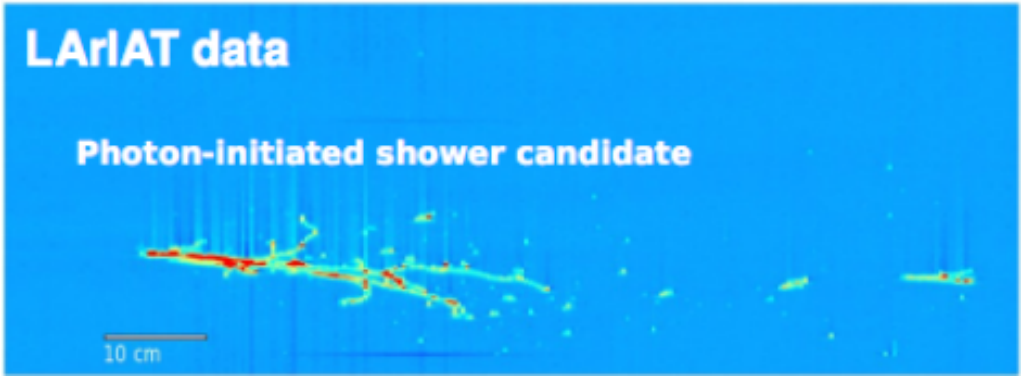
Track Reconstruction



Why do we care?

- LArTPCs are the neutrino detectors of choice for the SBN program and DUNE
- Using calorimetry and topology to distinguish E&M showers between **photons** and **electrons**
- LArIAT **calibrates** future neutrino experiments
  - Measurements of how neutrino interaction products behave in liquid argon
  - Methods to explore liquid argon technology



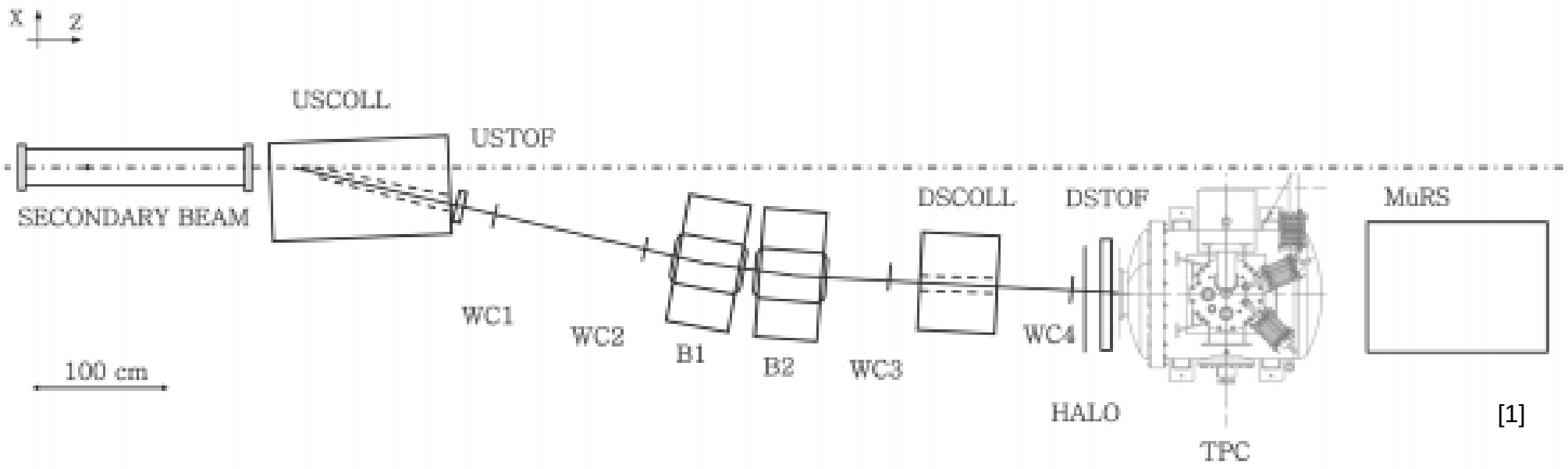


Test Beam Facility

- LArIAT ran in Fermilab's Test Beam Facility from 2015 to 2017
- Tertiary beam; Particles with momentum between 0.3 GeV/c and 1.4 GeV/c

[2]

Beamline

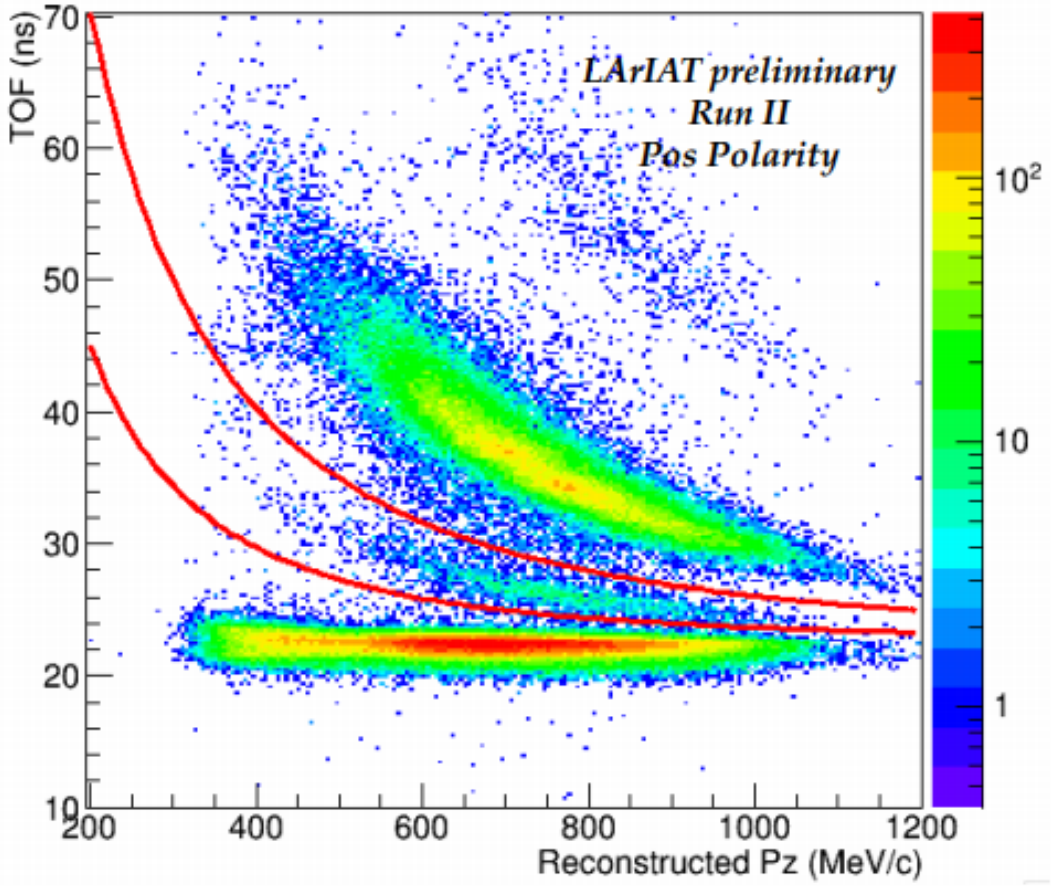


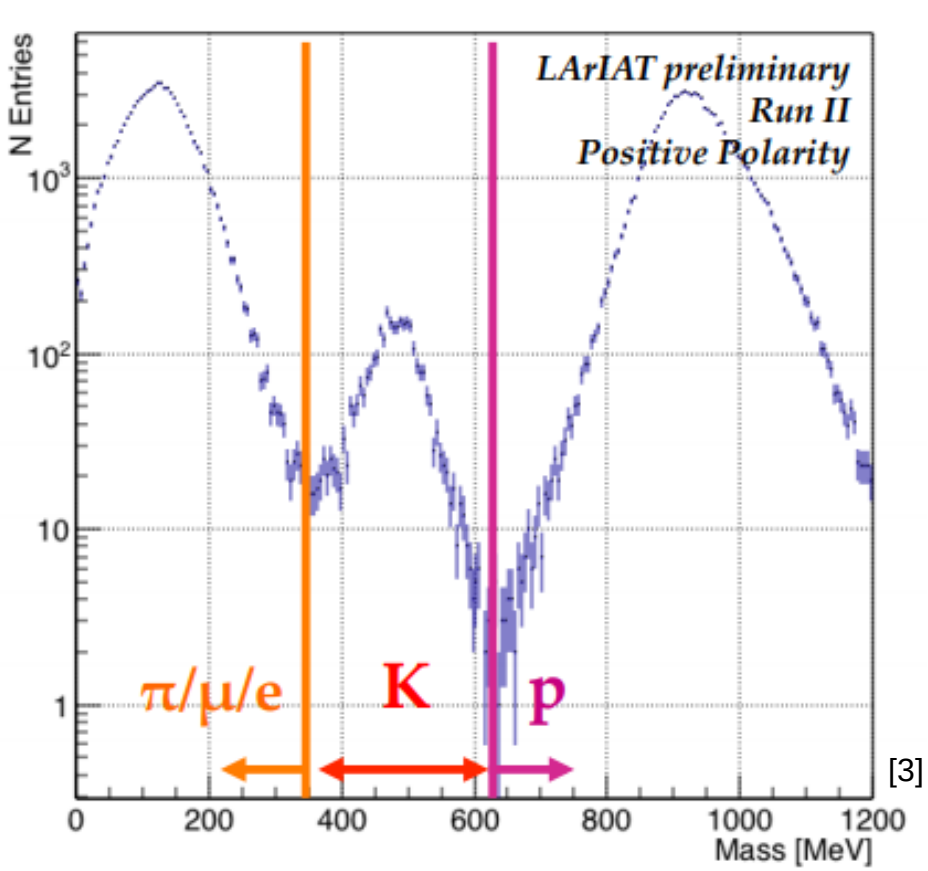
[1]

- 13° between secondary and tertiary beam.
- **Wire Chambers** record timing and location info.
- **Magnets**: Run at 60A and 100A. Curve particle path.
- **TOF** system made of PMT scintillator paddles.
  - Upstream: 6 cm x 10 cm; Downstream: 14 cm x 14 cm

LArIAT Analysis

- Wire Chamber Momentum Reconstruction
- Wire Chamber Particle Identification (PID)

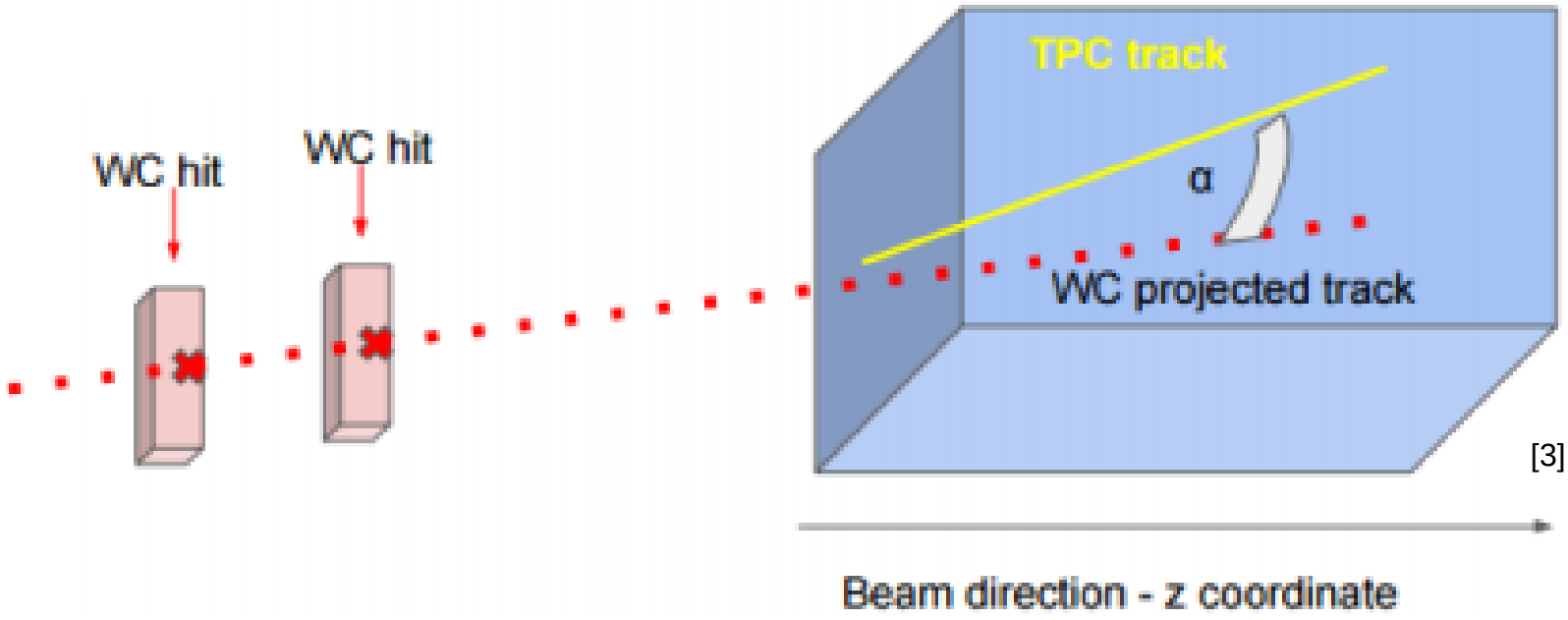




[3]

LArIAT Analysis

- Wire Chamber Momentum Reconstruction
- Wire Chamber PID
- Wire Chamber to TPC matching

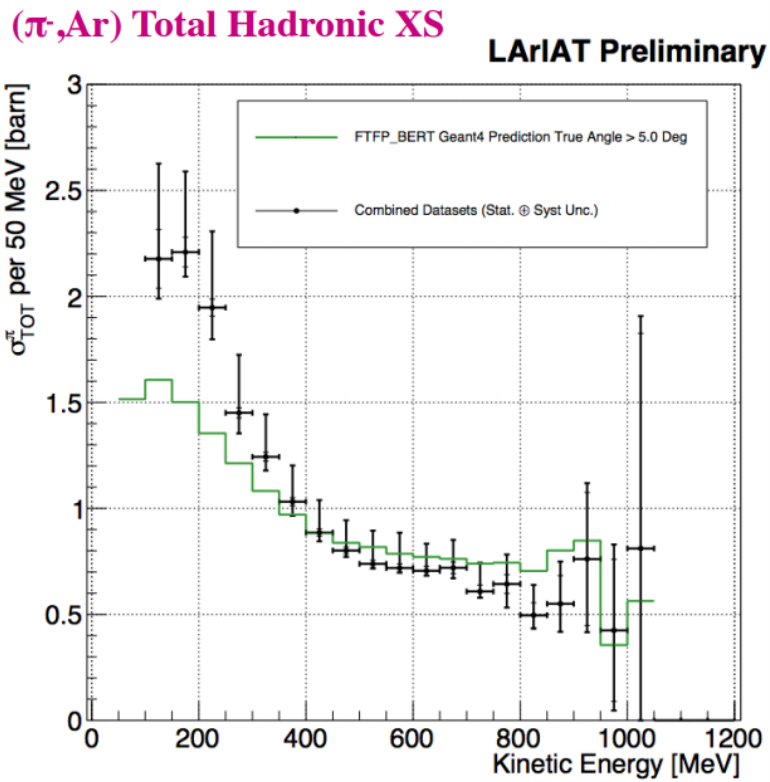


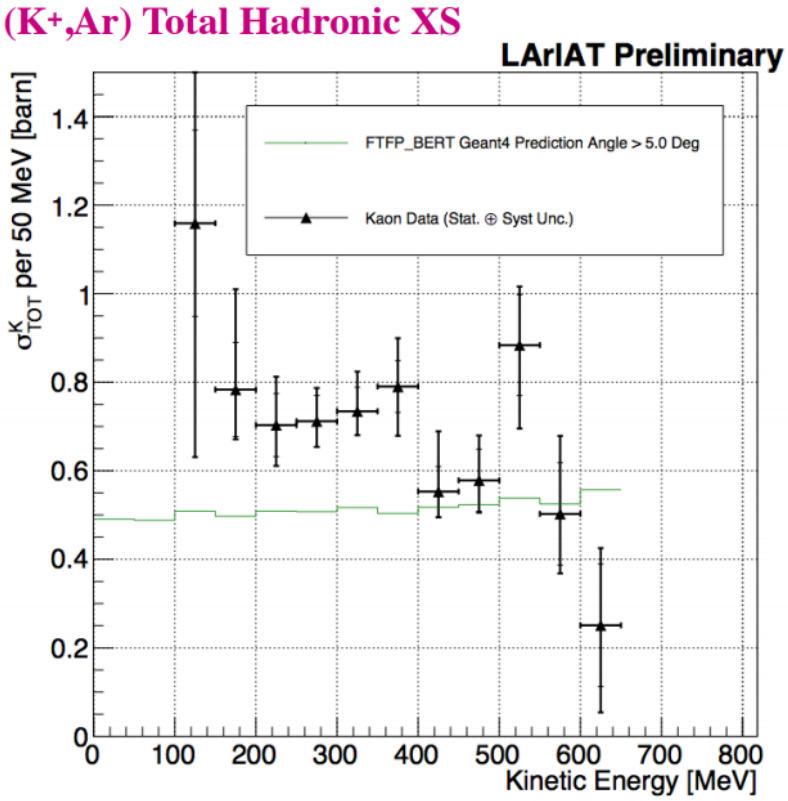
[3]

π- and K+ Cross-Section

Why?

- Novel Measurement
- Affects detection and measuring energy of hadrons in a neutrino experiment





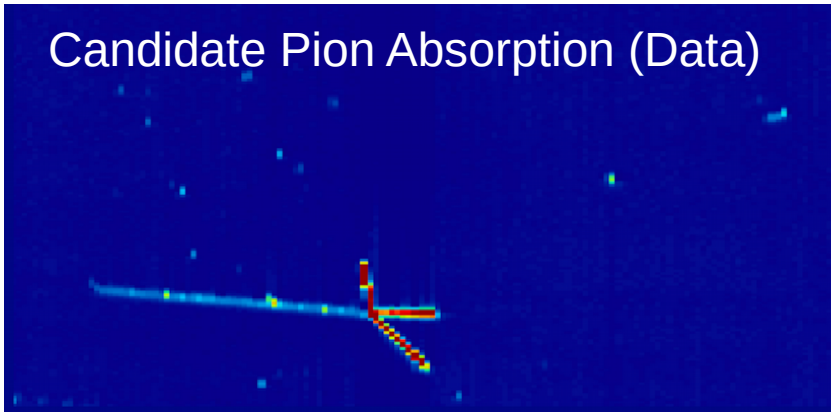
[3]

Pion Absorption Study

- Exploration of absorption π- kinematics
  - # protons
  - Energy of emitted protons
  - Energy loss

Why?

- Understanding the final state of neutrino interactions, where we don’t necessarily see the pions.
- What can pions in the nucleus do?

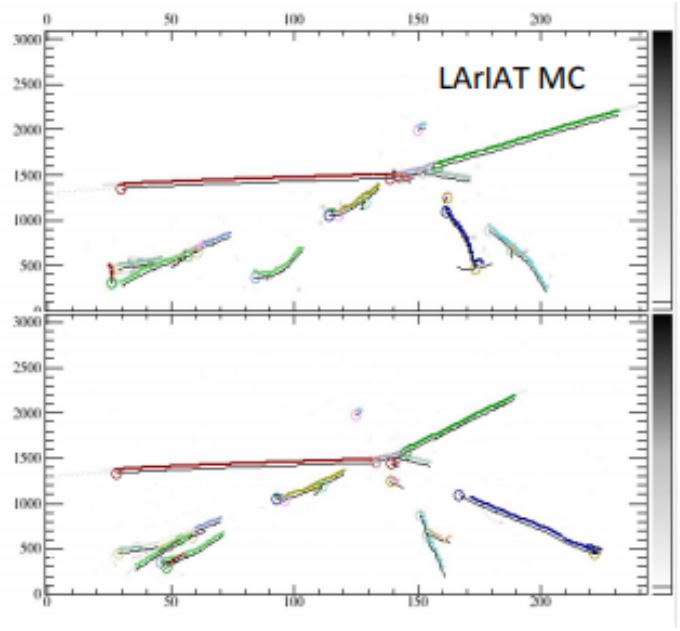


Antiproton Annihilation

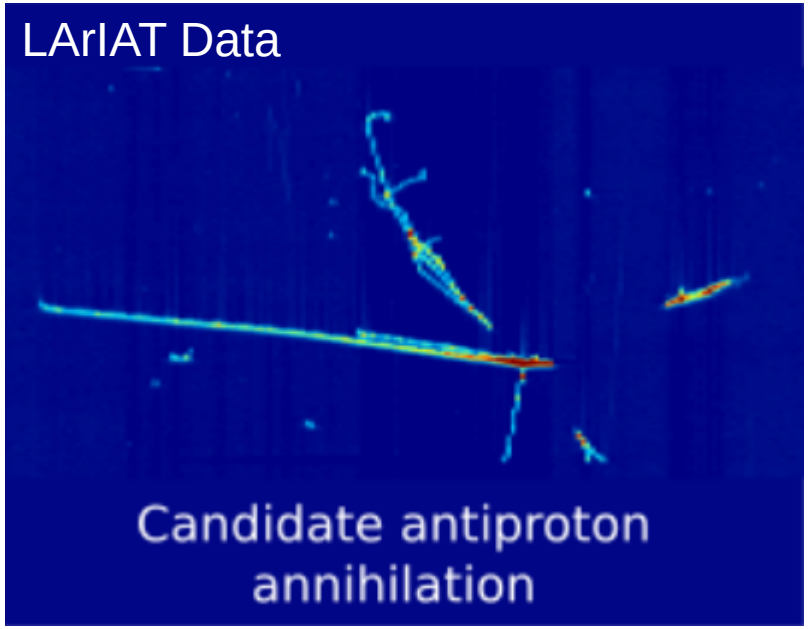
- Study the hadron star topology of proton-antiproton annihilation at rest.

  Why?

- Calibrate DUNE for neutron-antineutron oscillations, which also occur at rest.



[7]



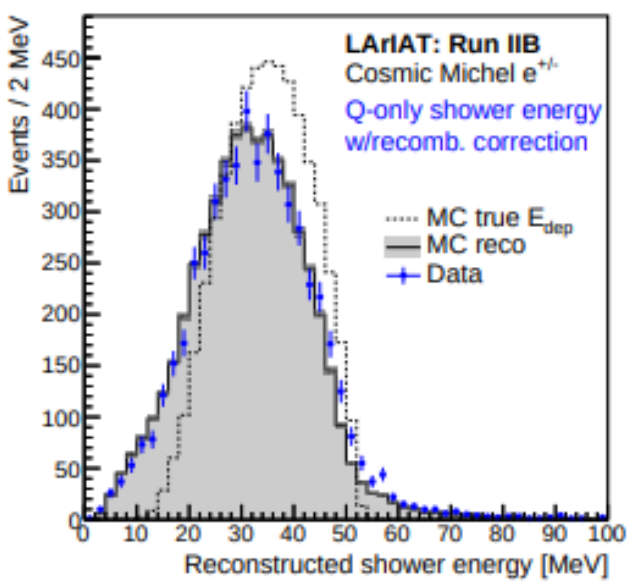
[1]

Michel Electron Calorimetry

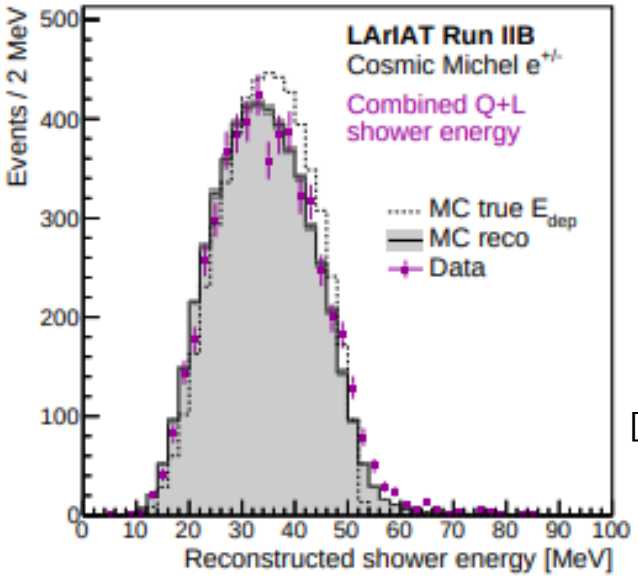
- Novel method of analysis!
- Using liquid argon scintillation light to reconstruct energy of 5-50 MeV electrons from cosmic muons.

  Why?

- Better understanding of low energy electron showers, such as from solar or supernova neutrinos in DUNE.



(a) 'Q-only' energy spectrum



(b) 'Q+L' energy spectrum

[4]

Summary

1) LArIAT is made up of the **beamline** and **LArTPC**
2) **Test beam** contains particles present in a neutrino interaction (muons, pions, electrons, kaons, protons)
3) **Beamline** has PID capabilities
4) **LArTPC** provides calorimetric and topological information
5) We use this to understand the behavior of these particles in liquid argon to **calibrate** LArTPCs for experiments like MicroBooNE, SBND, DUNE.
6) LArIAT allows us to develop new methods of analysis and make novel measurements!

References

[1] LArIAT Detector Paper (JINST): LArIAT DocDB 4000

[2] https://neutrinophysics.fnal.gov/facilities/charged-particle-beam-facilities/

[3] NuInt 18 - 12th International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region Contribution

[4] Michel Electron Calorimetry Paper: LArIAT DocDB 3646

[5] Matt King Updated Beamline Reco: LArIAT DocDB 3965

[6] https://www.fnal.gov/pub/science/particle-accelerators/images/accel-complex-animation.gif

[7] Vincent Basque Antiproton Annihiliation Presentation: LArIAT DocDB 4350

Backup Slides

LArIAT Analysis

- Monte Carlo Truth to develop measurement techniques

MC Truth

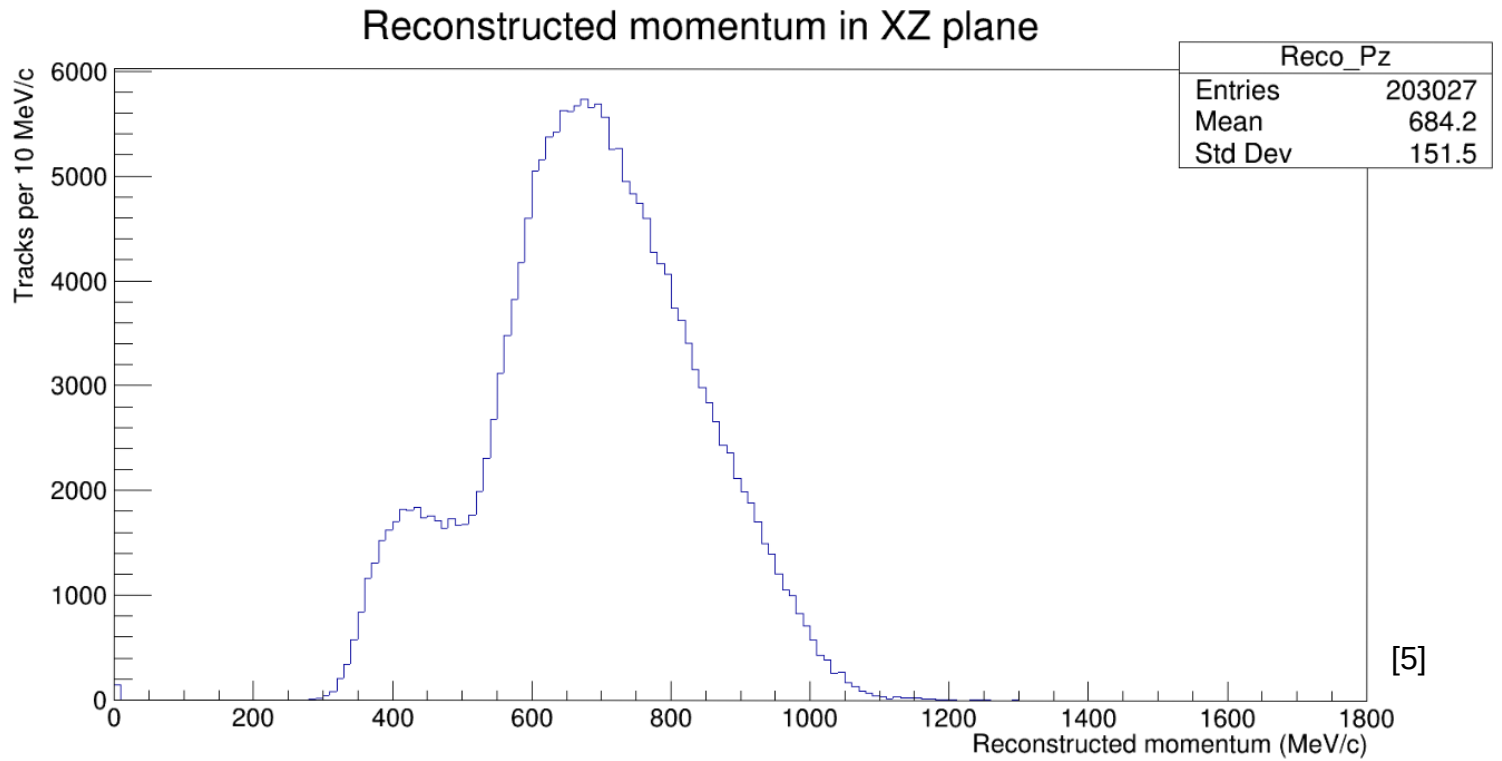
- Box mimics physics but doesn't necessarily have realistic values
- Create method for determining what's in the box (measurement).
- Check if your method (which doesn't assume knowledge of contents of box) matches what's in the box.

Data

- Apply method to data to make measurement.

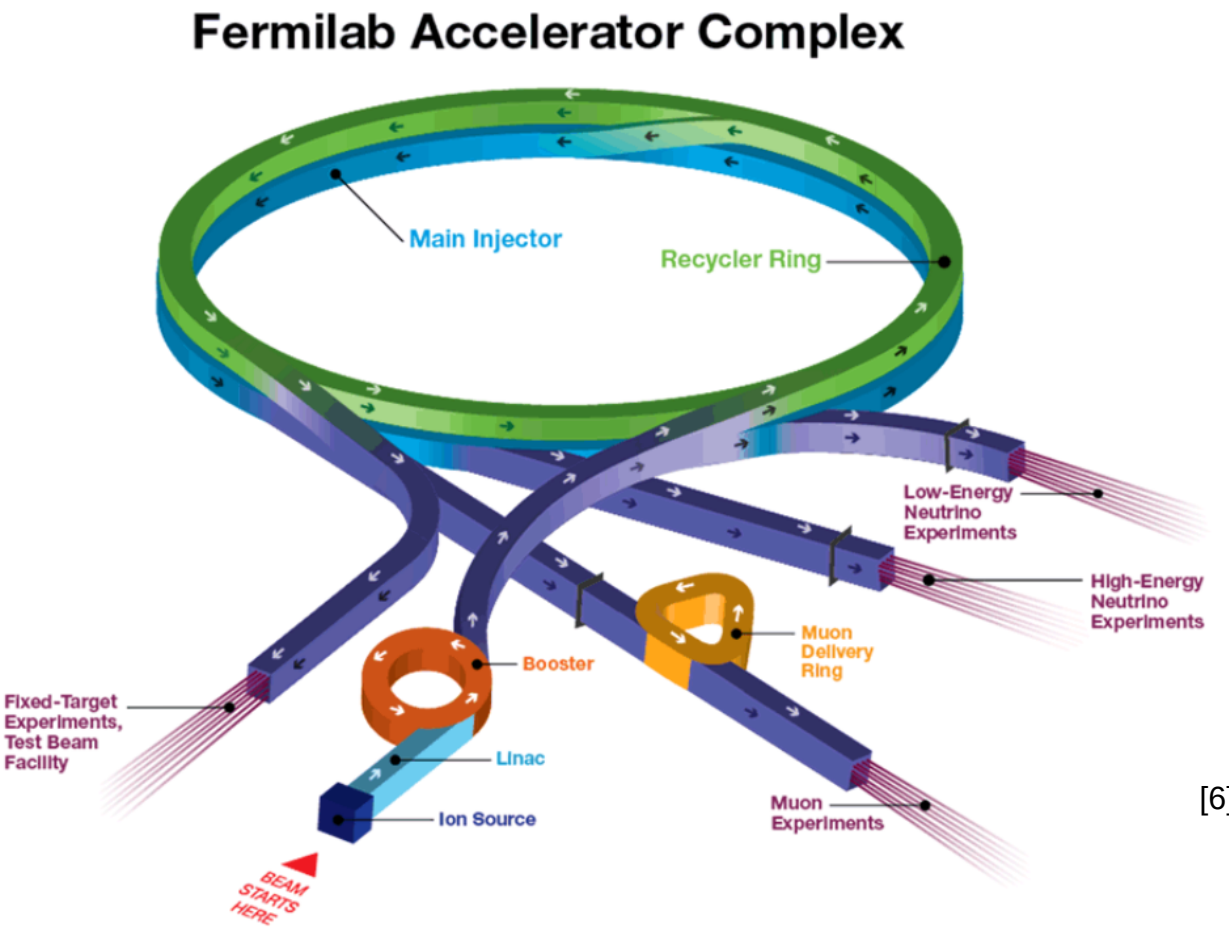
LArIAT Analysis

- MC Truth to develop reconstruction algorithm
- Wire Chamber Momentum Reconstruction



[5]

The Test Beam



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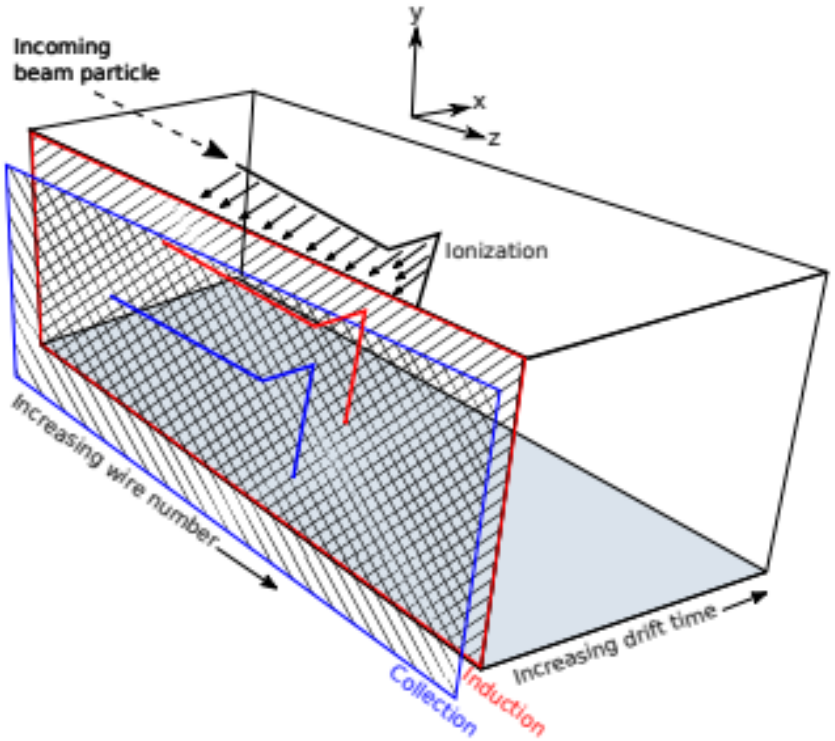
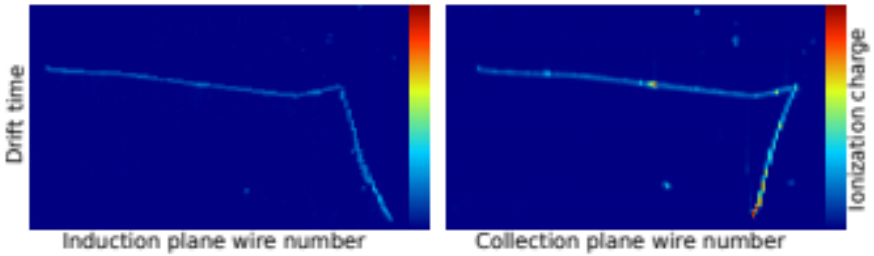
LArTPC Technology



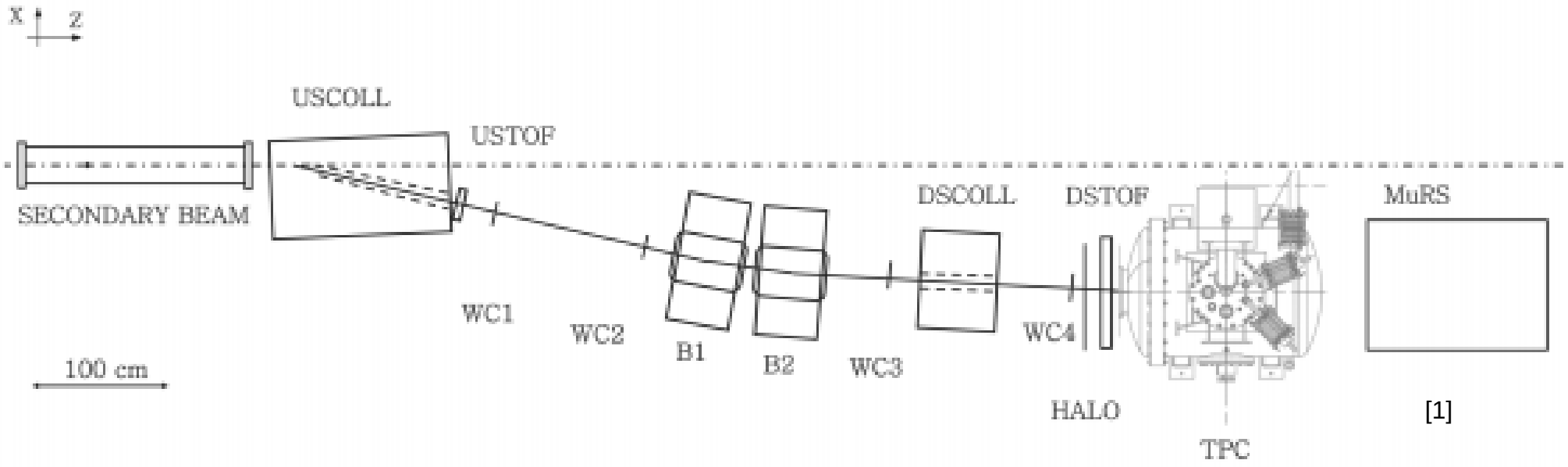


- TPC Active Volume: (47 cm x 40 cm x 90 cm)
- Induction Plane and Collection Plane: 40 cm x 90 cm in Run I, II, IIIA. 30 cm x 70 cm Run IIIB.
- 3mm wire spacing.

Liquid argon temperatures and electric field measurements via the ACP track method [1]

Run Period	Temperature (K)	Electric field (V/cm)
Run-I	89.4 ± 0.4	463.7 ± 10.6
Run-II	90.3 ± 0.3	465.9 ± 7.8
Run-III	90.3 ± 0.3	485.7 ± 12.0

Beamline



- 13° between secondary and tertiary beam. 10° bend.
- **Wire Chambers** record timing and location info.
- **Magnets**: gap height of 14.224 cm, gap width of 31.75 cm. Run at 60A and 100A.
- **TOF** system made of PMT scintillator paddles
  - Upstream: 6 cm x 10 cm; Downstream: 14 cm x 14 cm